

## ***Section 6: Conclusions***

***Disclaimer:*** This draft report was prepared to help the Department of Energy determine the barriers related to the deployment of new nuclear power plants but does not necessarily represent the views or policy of the Department.

## ***Project Objectives***

- The objectives of the project were to:
  - Build the business case for commercial deployment of new reactors.
  - Understand the risk management perspectives of key private investors, lenders, and industry, based on a strong understanding of the economics underpinning the production of electric power from new reactors and assessing the risks inherent in such development.
  - Evaluate market perspectives of the potential effectiveness of NE programs in addressing project development risks.
  - Describe under what conditions and financing structures new commercial reactors can be built and operated economically—and what private sector and DOE programs and financial mechanisms are critical to creating those conditions.
- Given the projected competitive position of new nuclear plants...
  - What risk factors most strongly impede a positive private sector investment decision relative to building new nuclear power plants?
  - What is the relative importance of these risk factors to nuclear power's competitiveness?
  - What critical risk hurdles will remain after DOE actions based on current program authority?
  - What actions must the private sector take to help manage critical risks to the construction and operation of new commercial reactors?
  - What actions does DOE need to consider taking—alone or with the private sector—to help break down remaining critical barriers to new nuclear facility development?
  - What alternative federal financing mechanisms for facilities (and, potentially, infrastructure) would be most effective in helping manage the remaining critical risks that appear to limit the competitiveness of new nuclear production facilities in U.S. electricity markets?

## *Initial Findings*

- Due foremost to (a) current conditions in electricity markets today, particularly adequate supply, moderate prices, and (b) the existence of a few “show-stopper” risks, it is unlikely that a nuclear power plant will be built by 2010 without government assistance.
- A substantial level of interest exists among the electricity utilities about building nuclear power plants in the future, particularly because of (a) the current excellent performance of existing plants (in terms of improved capacity factors and low price of delivered power) and (b) a desire in both the public and private sector for fuel supply diversity to help manage market risk, but...
- Perceived difficulty in managing several “show-stopper” and critical risks is limiting that interest.
- Difficulties in managing these risks associated with licensing, constructing, and commissioning the first new plants make it unlikely that, without additional government assistance, the first plant will be built.
- And, high capital costs, including final design costs, particularly for the first few plants threaten the market competitiveness of electricity generated in new nuclear plants, but...
- The long-term prospects for competitively priced nuclear power look very promising, especially in some power regions, once the critical issues controlling construction and operation of the first several plants have been surmounted.
- Even modest boosts to revenue through emissions trading programs or power purchase agreements could make a significant difference for utilities evaluating whether to proceed based on an IRR threshold.

## ***Controlling Risks Affecting New Plant Decisions: “Show Stoppers”***

- Several risks among the dozen discussed in Section 3 control decisions on moving forward with new nuclear plants. Some of these risks are considered “show-stoppers”: significant enough that, unless resolved, they will prevent go-forward decisions on new nuclear power plants.
- “Show-stopper” risks include the following:
  - Waste disposal risks, including transportation, related to the cost of disposing of spent fuel and, to a lesser degree, of low-level waste. In the unanimous view of utility and financial executives, no new plant will be undertaken without a permanent repository for spent fuel. Executives see the vote by the Congress to proceed on Yucca Mountain as a bellwether indicator on nuclear power. More narrowly, the vote increases the likelihood that disposal risks will ultimately be resolved after NRC completes licensing and the facility is constructed.
  - Accident risks of lost revenues and costs of remediation and recovery due to a major accident, *force majeure*, or a terrorist incident. In the unanimous view of utility and financial executives, without renewal of Price-Anderson indemnification coverage (including retrospective premiums and payments by utilities), no new plant will be undertaken because of the catastrophic financial consequences associated with such an event.
  - Uncertainty in necessary regulatory processes for new nuclear plants, particularly related to plant commissioning. In the unanimous view of utility and financial executives, these regulatory risks are the most difficult to mitigate using traditional risk management techniques because of the private sector’s inability to control them. Without certainty and finite timing, specifically for commissioning, no new plant will be undertaken; the potential to incur additional costs or, in a worst case scenario, have a non-operating plant is an unacceptable risk. Executives noted that certainty and finite timing cannot be assured for the first few new plants because new regulatory processes will not have been tested and proven (including legal testing). The new / improved regulatory processes in question include Early Site Permits (ESP) and the combined Construction and Operating License (COL) process, as well as Independent Testing, Analysis, and Acceptance Criteria (ITAAC), the commissioning process. The executives were strongly supportive of current DOE efforts in the regulatory area, citing the “show-stopper” level of these regulatory risks, but these efforts have not yet reached fruition and been tested.

## ***Controlling Risks Affecting New Plant Decisions: Other Major Risks***

- Several other critical risks among the dozen discussed in Section 3 also control decisions on moving forward with new nuclear plants, even though they are not “show stoppers”. These risks have a major impact on plant investment decisions because of their strong influence on economic returns.
- These other critical risks include the following:
  - Potentially high cost of power delivered relative to market prices.
  - Potential market risks.
- Several risks contribute to the possibility that nuclear power will be too costly from new plants, including:
  - Risk that regulation-related intervention in the courts will delay or prevent plant commissioning.
  - First-of-a-kind engineering (FOAKE) costs for new plant designs, a cost that is particularly critical for the first plant or two using a new design.
  - Risk that capital costs will be too high relative to electric prices from other sources.
  - Construction overrun risk, especially for plants using new designs, caused by new designs or *non*-regulatory construction problems.
  - On-site cleanup cost risk associated with accidents not covered by federal insurance offered under the Price-Anderson Act.
- Two issues impact demand and dispatch (or market) risk for electricity generated from new nuclear power plants:
  - The difficulty of predicting economic demand for electricity over the longer cycle of design, commissioning, and operation for new nuclear plants.
  - The risk that transmission availability will be inadequate. This risk is not likely to impair decisions to move forward for the first new plants, which are likely to be built at existing power plant sites where transmission capacity exists, but may become a factor in some regions over time if investment in the grid does not keep pace with demand.

## ***Sensitivity Analysis Sharpens Understanding of the Significance of the Controlling Risks***

- A model of the economics and financing of a new nuclear power plant was developed to enable an examination of:
  - The impact of changes in key cost elements that control the cost of electricity generated and internal rate of return (IRR), and
  - The sensitivities of these critical financial indicators to mitigation by several potential techniques, which can impact values for some of the key cost elements.
- Base case assumptions were formulated as a result of the interviews with equipment providers, E&C companies, electricity utilities, insurers, investment banks, and commercial lenders. These assumptions are either typical of today's higher-capital-cost power plants, particularly nuclear plants, or are compatible with executives' expectations.
- The sensitivity analysis confirms, based on cost and performance analysis for new designs, that nuclear power faces competitive challenges from other sources of power (e.g., gas, coal).
  - The base case cost of power for the first plant of a new design is expected to range from 3.8¢ / KWh to 4.2¢ / KWh (\$38 – \$42 / MWh), driven by an elevated plant capital cost (in the range, \$1500 – \$1700 / KWe), the utility's debt financing cost of 8%, the plant's debt : equity profile of 50 : 50, and the company's required IRR of at least 10% – 12%.
    - Subsequent early plants may be able to produce power at a cost of 3.7¢ / KWh (\$38 / MWh), if the capital cost improves to \$1300 / KWe and other assumptions are held constant.
    - The cost of power from an eventual "Nth" plant of a new design would be about 3.4¢ / KWh (\$34 / MWh), plus inflation, assuming that the plant's capital cost is \$1100 / KWe (the expected cost) and assuming the same cost of debt financing, debt : equity ratio, capacity factor, and required IRR.
    - Note that wholesale spot prices of electricity over the past year have ranged from 1.5¢ – 25¢ / KWh (\$15 – \$250 / MWh), depending on the season and the region, with most prices ranging from 2.0¢ – 4.0¢ / KWh (\$20 – \$40 / MWh). Spot prices have higher volatility and range than intermediate-term and long-term contract prices.

## ***Sensitivity Analysis Sharpens Understanding of the Significance of the Controlling Risks (continued)***

- The impact of changes in the following cost elements, plus revenue, was examined in the sensitivity analyses, as discussed in more detail in Section 5:
  - Power plant capital cost
  - Interest rates paid
  - Plant capacity factor (i.e., rate of utilization)
  - Fuel price / thermal efficiency
  - Construction period
  - Project debt-equity mix
- The results of the sensitivity analysis show that some variables influence the cost of power more than others.
  - Capital cost remains the most significant variable in driving electricity price competitiveness and financial return.
  - Borrowing costs, on a stand-alone basis, appear to have somewhat less impact on price competitiveness and financial returns.
  - Plant capacity factor changes have a comparatively small impact on IRR and competitiveness.
  - Construction delays have a negative impact on IRR and plant competitiveness. Reducing construction delays improves IRR most for lower-capital-cost plants.
- Fuel prices and plant efficiency drive electricity price competitiveness and financial return the least among the variables tested, primarily because they are already low (~5 mil / KWh).
- IRR is fairly sensitive to project debt : equity mix, but executives consulted during this study indicated that financial markets are not likely to be flexible about project debt : equity mix because of rating agency concerns regarding leverage and the impact on balance sheets from a credit quality perspective.
- The sensitivity analysis supports the conclusion that industry is not likely to build a first unit without government assistance because the first unit is unlikely to be competitive in today's market and its financial performance will fall below IRR hurdle requirements. High first-of-a-kind engineering (FOAKE) costs, the projected high cost of reactor equipment, the long lead time for new plants, and increased uncertainty about electricity prices in a partially deregulated environment combine to make the first new nuclear units an unattractive business proposition, unaided.
- Importantly, however, the sensitivity analysis shows that, once “show-stopper” issues are resolved and early units are built, nuclear power is likely to be competitive, particularly if capital costs drop below \$1100 / KWe due to learning curve effects and removal of contingencies, or if power prices drift to somewhat higher levels.

## ***Some Risk Mitigation Capacity Exists and More is “In Progress”***

- As noted earlier, certain “show-stopper” risks and other critical risks challenge companies that are considering building and operating new nuclear plants. A variety of mitigation techniques that have been used or are likely to be used will be applied to new nuclear plants.
- Foremost, DOE is working valuably to address the “show-stopper” disposal risk (through licensing and construction of the Yucca Mountain repository), accident risk (through reauthorization of the Price-Anderson indemnification insurance), and commissioning risk (through collaboration with NRC on the new combined Construction and Operating License [COL] and ITAAC processes). Of course, until favorable results of this work are secured and tested in court, these risks will remain unmanageable in the private sector.
- DOE is also working valuably to simultaneously strengthen and accelerate regulatory processes that are aimed at site permitting (the new Early Site Permit [ESP] process) and the combination of construction and operating licenses (COL process). Executives consulted in the study, however, view these programs with caution because they have not yet been finalized, and are untried and untested; they must be shown to be effective.
- The special issues associated with a nuclear facility, including a unique regulatory structure and the large capital costs of construction, thus test the limits of the market’s capacity. Several techniques have been used by the private sector in existing plant transactions—or are likely to be used—to help manage critical risks that impact financings, including:
  - A financing structure that uses the strong balance sheets of an integrated generation and utility company.
  - Use of parent company guarantees to fully support completion and commissioning risks.
  - Vendor warranties through shakedown and full operations to help manage the risk of a new reactor design.
- The risks associated with construction of high-capital-cost plants using a new reactor design are similarly difficult to manage. A combination of mitigation measures is likely to be utilized by the private sector, including fixed-price, turn key contracts with engineering and construction (E&C) firms and carefully drawn financing structures. In addition, extended warranties from the equipment vendors of new designs may be required to help mitigate the risk of non-performance.
- In consideration of the sheer size of a new nuclear project, the financial community is likely to expect power generators to have an off-take contract (i.e., a fixed-price contract) for a substantial portion, if not the entire amount, of the power produced—with a substantial contract term.



## ***Critical Steps to New Nuclear Power Plants Beginning in 2010***

- As discussed throughout the report, several areas of elevated risk make it unlikely that new nuclear plants will be built in the near term in the United States without government participation and support, at least until the first few plants have been built and operated successfully. While industry and financial firms are capable of mitigating to varying degrees the risks associated with the development of new nuclear power plants using new designs, industry and financial community assessments of the risks indicate that it is unlikely that these capabilities will be sufficient to support new nuclear plant development in a timeframe that leads to commercial operation of the first plant by 2010.
- Industry and financial participants were unanimous in their view that three major areas of risks are so important that they are “show-stopper” risks, areas that are absolute roadblocks to a go-forward investment decision on a new nuclear generating facility. These three “show-stopper” risks are waste disposal, accident, and the lack of certain and finite regulatory processes that lead to plant commissioning. Without decisive action on these three areas of risk, no power developer will elect to go forward. Even then, until improved regulatory processes are court-tested and affirmed, power developers and their investors and lenders will not act.
- The analysis shows that several potential risk mitigation measures are essential to the management of other critical risks, as defined and discussed in Section 3.

We have matched these critical risks with potentially effective mitigation solutions, as follows:

- Regulatory risk not due to contractor fault that manifests itself in increased financing costs due to unforeseen and uncontrollable delays can best be mitigated through a stand-by credit facility, sized to address and capitalize these costs. In a worst-case scenario, lenders and equity investors can be made whole through government-provided principal buy-down or partial equity take-out provisions (similar to a loan guarantee).
- A persistent, though short-term, problem facing the industry’s equipment vendors—first-of-a-kind engineering costs for new plant designs—could potentially be addressed through a government-provided, quasi-equity contribution designed to infuse capital into the plant development and construction period with a reduced impact on debt service coverage. Payment will be senior to common equity returns, but subordinate to other debt, and may have a trigger (e.g., “sub-debt” payments might begin after the plant’s capacity factor reaches 85%). Such a facility would be targeted at the first few plants using a new design and would not be available for later plants.

## ***Critical Steps to New Nuclear Power Plants Beginning in 2010(continued)***

– Estimates of high capital costs for new nuclear plants lead to projections that power costs will be in excess of market clearing rates for early plants. Mitigation options are designed to reduce borrowing costs, a significant component of operating expenses or, alternatively, to augment revenues from power sales. Two options exist to reduce borrowing costs: subsidized federal loans and the allowance of tax-exempt financing for new nuclear power plants.

- The former has the added advantage of having a federal energy credit program absorb project credit risk, while providing a source of low-cost financing.
- The latter, tax-exempt financing, provides a low-cost source of capital, but relies on tax-exempt investors to assess and accept the risks of project performance and ongoing operations.

Two options also exist to augment revenues:

- A federal power purchase agreement at above-market rates over varying contract terms for varying percentages of plant output, which could provide additional project revenues while potentially limiting the impact of assistance on the federal budget.
- Emissions credits, even if small, for nuclear power—a clean source of electricity, which would also enhance financial performance while at the same time leveling the playing field versus more carbon-intensive methods of power generation.

– The risk of unforeseen construction cost overruns caused by new designs or non-regulatory construction problems is potentially outside the bounds of the financial capabilities of EPC firms. Similarly, contracting firms may command risk premiums for fixed-price turn key projects that drive capital costs into an uncompetitive range. Government-provided standby credit facilities, sized to cover worst-case scenarios, could provide project lenders with meaningful comfort against these concerns, enabling financings to go forward.

– Finally, insurance capacity for the nuclear industry has long relied on pooling arrangements supported by government under the Price-Anderson Act. Especially post-9/11, concerns related to terrorist attacks and other forms of political violence have given rise to the possibility that the underwriting capacity of private-market insurers may be limited or too expensive. Other risks, such as on-site cleanup costs, have remained outside the bounds of policy limits, under the tacit assumption that the government will take up the role of insurer of last resort. New plants coming on line will likely exacerbate these latent problems and may require reworking of the existing pooling arrangements and / or additional government indemnification in order to continue to draw the necessary participation from private-market insurers.

## ***Critical Steps to New Nuclear Power Plants Beginning in 2010(continued)***

- While this study has laid out a series of critical risk categories and potential solutions to address them, we believe that a useful way to conclude our report is to lay out a vision of a number of immediate steps to be implemented to enable DOE's nuclear power objectives to be met.
- Once "show-stopper" issues are resolved and early units are built with support from mitigants, nuclear power is likely to be competitive, particularly if capital costs drop below \$1100 / KWe, or if power prices drift to slightly higher levels.
- By their very nature, it will be difficult or impossible to achieve immediate resolution to the "show-stopper" risks outlined earlier. Unless they are resolved, however, industry and financial executives have indicated that no new plant development will take place. In that regard, DOE should continue its efforts in support of the reenactment of the Price-Anderson Act, the development of Yucca Mountain, and ongoing work on regulatory issues with a high priority.
- We believe that addressing first-of-a-kind engineering costs through the use of a government-provided equity investment facility clearly stands next in line in the sequence of risks to be addressed; the ongoing work to improve the efficacy and cost-competitiveness of new reactor designs for the U.S. market is on the critical path to success. DOE efforts to help manage these costs must begin as soon as possible.
- In conjunction with these efforts, DOE should establish a diverse and robust energy credit program that contains a number of options because the range of controlling risks to new high-capital-cost power projects—and other high-priority energy systems—cannot be addressed with one or a few mitigation techniques. We believe that a comprehensive energy credit program can be designed that is structured to incorporate a variety of tools, including credit facilities to address regulatory risk, standby facilities to provide backstop against construction cost overruns, and a direct loan option to provide low-cost capital on either a senior or a subordinate basis with favorable amortization terms of up to 30 years or, perhaps, longer.
- DOE should seek to design an energy credit program that provides the Department with broad flexibility to use a variety of innovative finance techniques to leverage the federal budget while attracting private investment.
- Lastly, DOE should seek the inclusion of nuclear power, a clean source of electricity, in any U.S. carbon emission credit program. Such a program could be an important technique for both enhancing the financial performance of nuclear power plants *and* leveling the playing field for nuclear power versus more carbon-intensive power sources. Such a program might improve plant revenues in the range of 5% – 10%, if carbon credits were bid near \$2 – \$5 per ton of CO<sub>2</sub>. Current carbon trades run in the \$1 – \$3 range per ton of CO<sub>2</sub>.